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Standardized catch rates of Atlantic sharpnose and bonnethead sharks from the SEAMAP-South Atlantic Shallow Water Trawl Survey

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Summary

This document presents an updated analysis of the relative abundance of Atlantic sharpnose and bonnethead sharks from the SEAMAP-SA Shallow Water Trawl Survey for 1989-2011. Time series data from this survey were standardized with Generalized Linear Mixed Model (GLMM) procedures. Both series showed increasing trends. Examination of lengths of Atlantic sharpnose and bonnethead sharks over the time period considered revealed no trend. Length-frequency information revealed that mostly immature individuals of these species area caught, but adults are also present.

1. Background

Time series from the SEAMAP (Southeast Area Monitoring and Assessment Program) survey were first examined for the 2002 stock assessment of small coastal sharks (Cortés 2002) for the period 1989-2001 and for SEDAR 13 for the period 1989-2005 (Cortés and Boylan 2007). The SEAMAP-South Atlantic Shallow Water Trawl Survey samples nearshore areas where commercial shrimping occurs along the southeastern coast of the U.S. between Cape Hatteras, North Carolina and Cape Canaveral, Florida (ASMFC 2000). In this document, we derived updated indices of relative abundance of Atlantic sharpnose and bonnethead sharks for the period 1989-2011 using the same methodology used in SEDAR3-DW-14.

2. Materials and Methods

Data

Methodological details of the SEAMAP survey can be found in various documents that have been made available in previous SEDAR Data Workshops (SEAMAP 2000 and 2005 reports, SEAMAP methods). Briefly, cruises are conducted in spring (early April-mid-May), summer (mid-July-early August), and fall (October-mid-November) in coastal waters between Cape Hatteras, North Carolina, and Cape Canaveral, Florida. Paired trawl nets are towed for 20 minutes during daylight hours only, thus catch rates are expressed on a tow basis. The survey uses a stratified random sampling design, where the strata correspond to different latitudinal areas and depth zones. We used the following variables for this analysis: season (consisting of spring, summer, and fall), region (Florida, Georgia, South Carolina, and North Carolina), and year, as well as interactions between each pair of these factors. Atlantic sharpnose and bonnethead sharks are the species most commonly caught in this survey. Data were analyzed for the period 1989-2011.

Statistical analysis

Relative abundance indices were estimated using a Generalized Linear Model (GLM) approach assuming a delta lognormal model distribution. A binomial error distribution was used for modeling the proportion of positive sets with a logit function as link between the linear factor component and the binomial error. A lognormal error distribution was used for modeling the catch rates of successful sets, wherein estimated CPUE rates assume a lognormal distribution (lnCPUE) of a linear function of fixed factors. The models were fitted with the SAS GENMOD procedure (SAS Institute Inc. 1999) using a forward stepwise approach in which each potential factor was tested one at a time. Initially, a null model was run with no explanatory variables (factors). Factors were then entered one at a time and the results ranked from smallest to greatest reduction in deviance per degree of freedom when compared to the null model. The factor which resulted in the greatest reduction in deviance per degree of freedom was then incorporated into the model if two conditions were met: 1) the effect of the factor was significant at least at the 5% level based on the results of a Chi-Square statistic of a Type III likelihood ratio test, and 2) the deviance per degree of freedom was reduced by at least 1% with respect to the less complex model. Single factors were incorporated first, followed by fixed first-level interactions. The year factor was always included because it is required for developing a time series. Results were summarized in the form of deviance analysis tables including the deviance for proportion of positive observations and the deviance for the positive catch rates.

Once the final model was selected, it was run using the SAS GLIMMIX macro (which itself uses iteratively re-weighted likelihoods to fit generalized linear mixed models with the SAS MIXED procedure; Wolfinger and O'Connell 1993, Littell et al. 1996). In this model, any interactions that included the year factor were treated as a random effect. Goodness-of-fit criteria for the final model included Akaike's Information Criterion (AIC), Schwarz's Bayesian Criterion, and –2* the residual log likelihood (-2Res L). The significance of each individual factor was tested with a Type III test of fixed effects, which examines the significance of an effect with all the other effects in the model (SAS Institute Inc. 1999). The final mixed model calculated relative indices as the product of the year effect least squares means (LSMeans) from the binomial and lognormal components. LSMeans estimates were weighted proportionally to observed margins in the input data, and for the lognormal estimates, a back-transformed log bias correction was applied (Lo et al. 1992).

The relative abundance indices obtained were compared to those from SEDAR 13, which examined the period 1989-2005. Additionally, we examined length-frequency distributions for Atlantic sharpnose shark and bonnethead and trends in length for individuals of these two species that were measured (from 1994 on).

3. Results

Catch rates

Atlantic sharpnose shark—Factors retained for the proportion of positive tows were season, year, year*season, year*region, and region*season; and for the positive catches, the factors season, year, year*region, and year*season were retained in that order (Table 1). The index is almost identical to that developed previously (Cortés and Boylan 2007) and shows an increasing trend (Fig. 1). Catches increased during 2001-2011 with respect to those in 1989-2000 as did the effort (mean effort in 1992-2000=227 tows vs. mean effort in 2001-2011=314 tows) (Fig. 2) and the proportion of positive tows (Fig. 1). Diagnostic plots showed good agreement with model assumptions and there were no systematic patterns in the residuals (Fig. 3). The annual index values with CVs are listed in Table 2.

Bonnethead shark—Factors retained for the proportion of positive tows were region, season, year, year*season, and region*season; and for the positive catches, the factors region, year, and year*region, and year*season were retained in that order (Table 3). The index is also almost identical to that developed previously (Cortés and Boylan 2007) and shows an increasing trend (Fig. 4). As above, the increased catch and effort in 2001-2011 vs. 1992-2000 coincides with an increase in CPUE and the proportion of positive tows in 2001-2011 (Fig. 4). Diagnostic plots showed good agreement with model assumptions and there were no systematic patterns in the residuals (Fig. 5). The annual index values with CVs are listed in Table 4.

Trends in size

Examination of length-frequency distributions for Atlantic sharpnose shark revealed that most animals were immature—with the smallest two size classes clearly dominating—, although mature animals were also caught (Fig. 6). A similar pattern was observed for bonnethead, albeit there were proportionally more mature animals (Fig. 7). There was no trend in length over the time period considered for any of the two species examined (Fig. 8).

4. Discussion

The two indices of relative abundance examined showed markedly increasing trends. It must be noted that sharks became a priority species for SEAMAP-SA in 2001, but that should not have affected catch rates as these species were unofficially sampled in the exact same way since about 1994. The increase in the total number of tows per year starting in 2001 may explain, at least in part, the increases in the time series from 2001 to 2011, although both indices also fluctuated during that period. However, in addition to the increase in the number of stations sampled, the station allocation scheme also changed in 2001 from a fixed number of stations per stratum to an optimal allocation scheme whereby strata with higher variability were allocated more stations, and vice versa. This was an attempt to lower overall variability and it is possible that areas of high variability tend to have higher shark density, although there is no evidence to support this. The lack of trend observed in the scatter plots of lengths also suggests that the stocks of these two species have remained stable over the time period analyzed.

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Table 1. Factors retained in the model of proportion of positive sets and positive catch of **Atlantic sharpnose sharks** for SEAMAP-SA trawl data.

Proportion positive	Degrees of freedom	Deviance	Log-likelihood
Null model	6184	8566	-4283
Final model SEASON YEAR YEAR*SEASON YEAR*REGION REGION*SEASON	6041	6287	-3143

Positive catches	Degrees of freedom	Deviance	Log-likelihood
Null model	3206	3796	-4821
Final model SEASON YEAR YEAR*REGION YEAR*SEASON	3069	2622	-4227

Table 2. Estimates of mean annual CPUE (numbers of sharks per 20-minute tow) and coefficients of variation (CV) for **Atlantic sharpnose shark** for SEAMAP-SA trawl data.

Year	Mean CPUE	CV
1989	3.114	0.334
1990	2.784	0.328
1991	2.968	0.306
1992	2.711	0.319
1993	2.080	0.349
1994	1.468	0.389
1995	2.935	0.275
1996	1.693	0.374
1997	3.695	0.286
1998	2.530	0.318
1999	2.591	0.313
2000	3.660	0.291
2001	3.227	0.246
2002	5.152	0.223
2003	5.296	0.252
2004	3.684	0.256
2005	4.587	0.289
2006	6.410	0.24
2007	6.420	0.202
2008	4.451	0.226
2009	5.618	0.206
2010	4.674	0.233
2011	4.11	0.226

Table 3. Factors retained in the model of proportion of positive sets and positive catch of **bonnethead sharks** for SEAMAP-SA trawl data.

Proportion positive	Degrees of freedom	Deviance	Log-likelihood
Null model	6184	7341	-3670
Final model REGION SEASON YEAR YEAR*SEASON REGION*SEASON	6107	5545	-2772

Positive catches	Degrees of freedom	Deviance	Log-likelihood
Null model	1734	1786	-2487
Final model REGION YEAR YEAR*REGION YEAR*SEASON	1602	1214	-2152

Table 4. Estimates of mean annual CPUE (numbers of sharks per 20-minute tow) and coefficients of variation (CV) for **bonnethead shark** for SEAMAP-SA trawl data.

Year	Mean CPUE	CV
1989	0.773	0.551
1990	1.346	0.36
1991	2.068	0.344
1992	1.436	0.323
1993	1.004	0.409
1994	1.604	0.346
1995	1.706	0.322
1996	0.704	0.443
1997	1.527	0.331
1998	1.23	0.357
1999	1.13	0.382
2000	1.645	0.339
2001	2.246	0.274
2002	3.35	0.238
2003	2.871	0.256
2004	1.29	0.341
2005	2.638	0.266
2006	3.856	0.246
2007	3.001	0.269
2008	2.783	0.274
2009	3.541	0.233
2010	2.663	0.25
2011	1.752	0.287

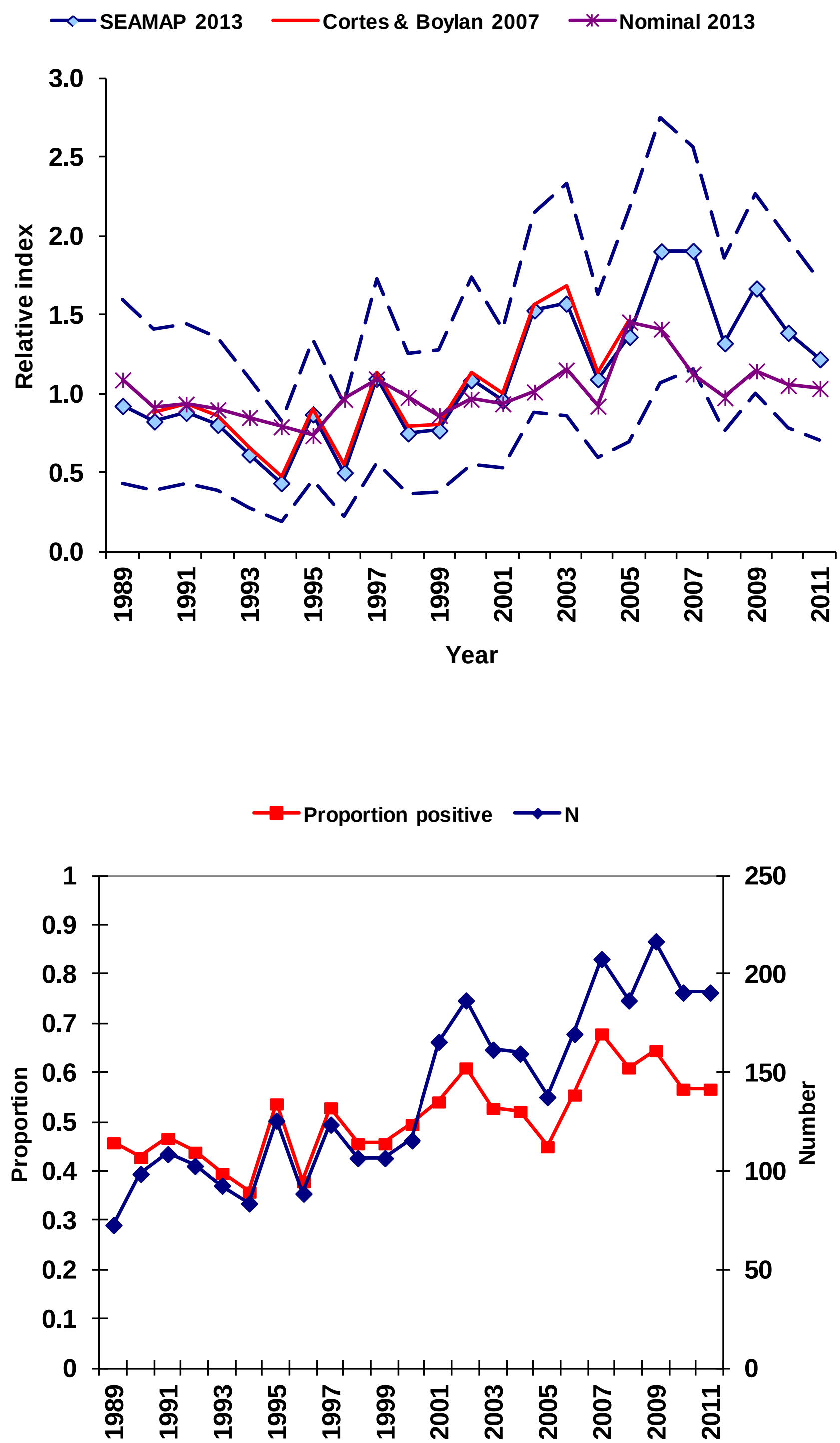


Figure 1. Standardized CPUE (in number) and 95% confidence intervals for **Atlantic sharpnose shark** from the SEAMAP trawl survey compared to a previous study. All indices are standardized to the mean of the overlapping years. The lower panel shows the proportion of positive sets and sample size by year.

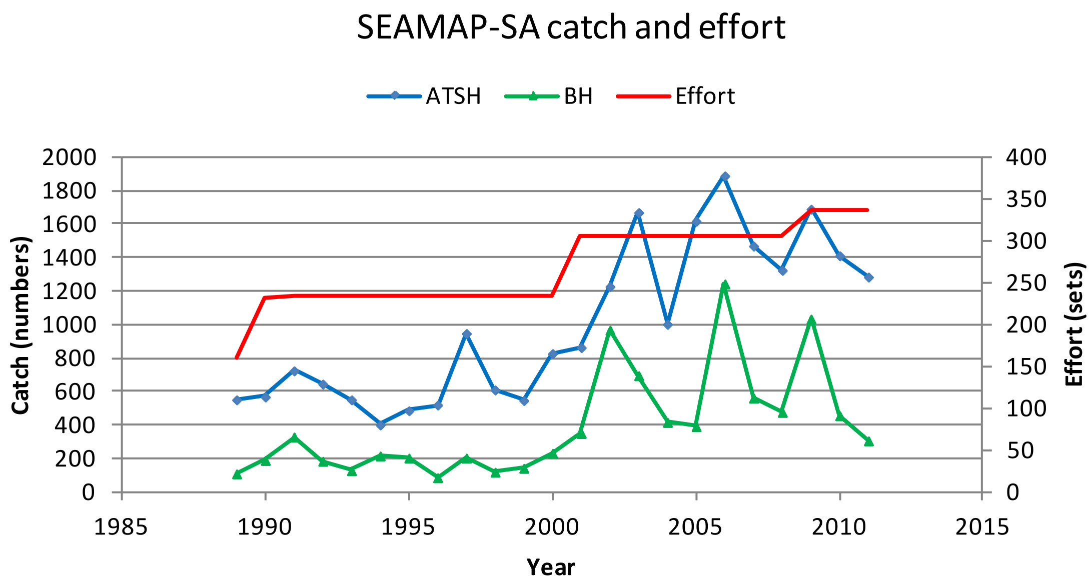


Figure 2. Catch and effort (number of tows) per year in the SEAMAP-SA trawl survey.

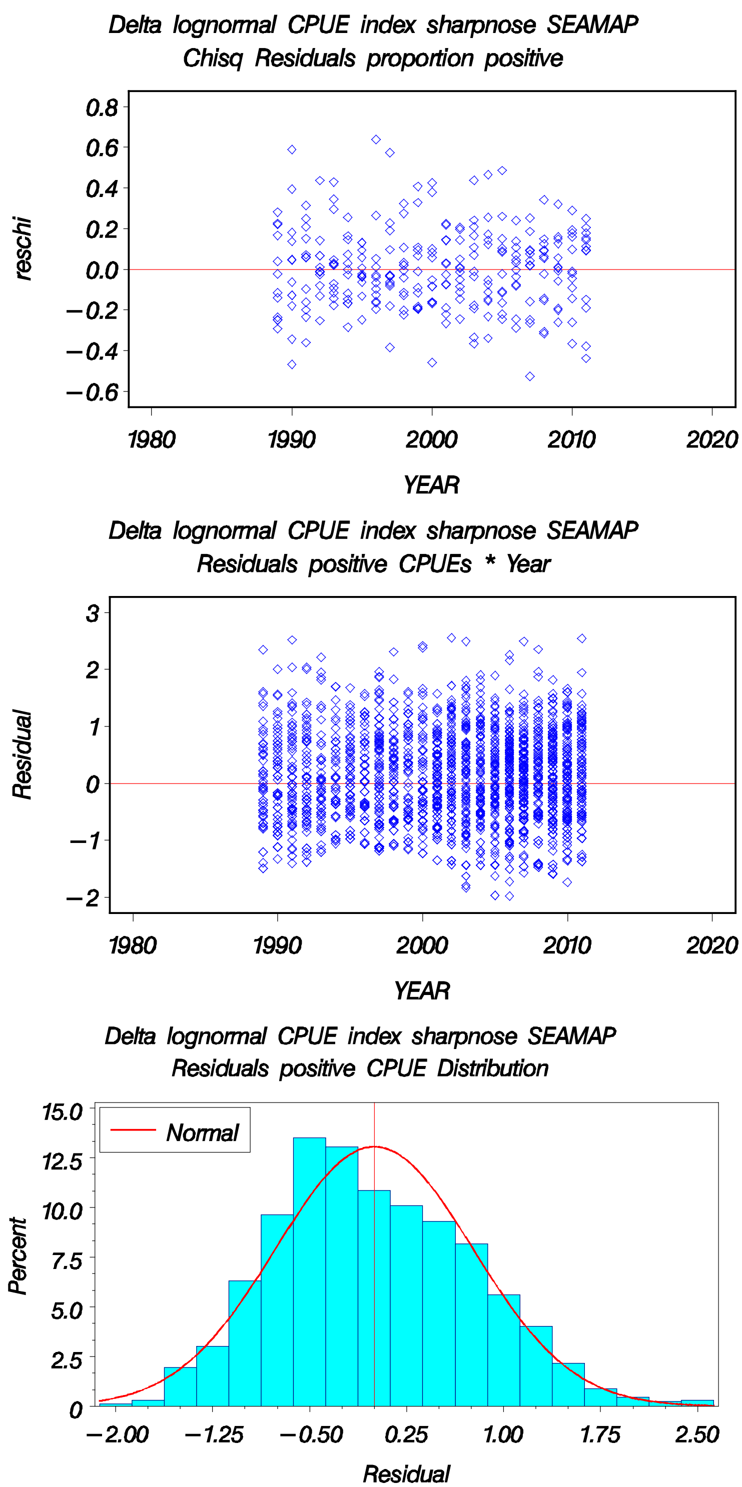


Figure 3. Diagnostic plots of CPUE model from SEAMAP trawl data for **Atlantic sharpnose shark**. Top: residuals of proportion positive sets; middle: residuals of positive catch; bottom: residual positive catch distribution.

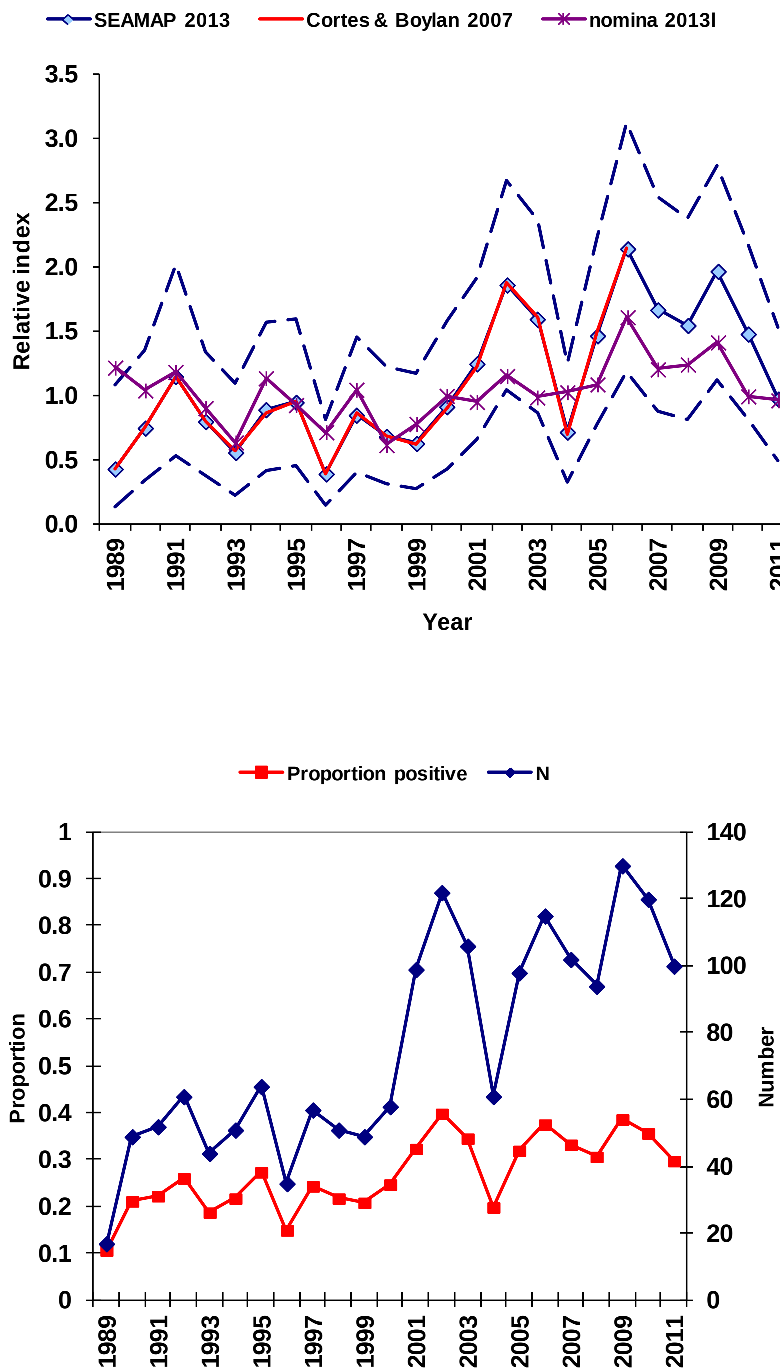


Figure 4. Standardized CPUE (in number) and 95% confidence intervals for **bonnethead shark** from the SEAMAP trawl survey compared to a previous study. All indices are standardized to the mean of the overlapping years. The lower panel shows the proportion of positive sets and sample size by year.

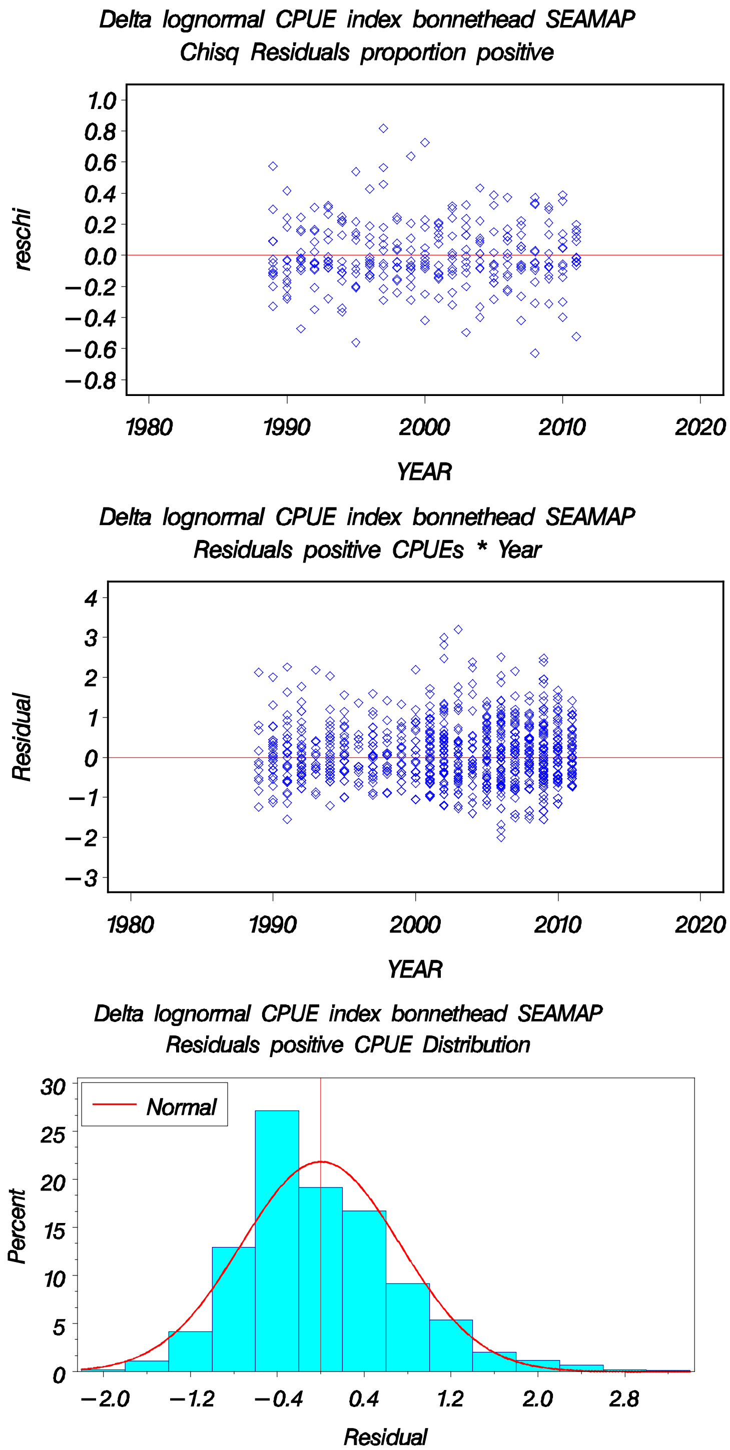


Figure 5. Diagnostic plots of CPUE model from SEAMAP trawl data for **bonnethead shark**. Top: residuals of proportion positive sets; middle: residuals of positive catch; bottom: residual positive catch distribution.

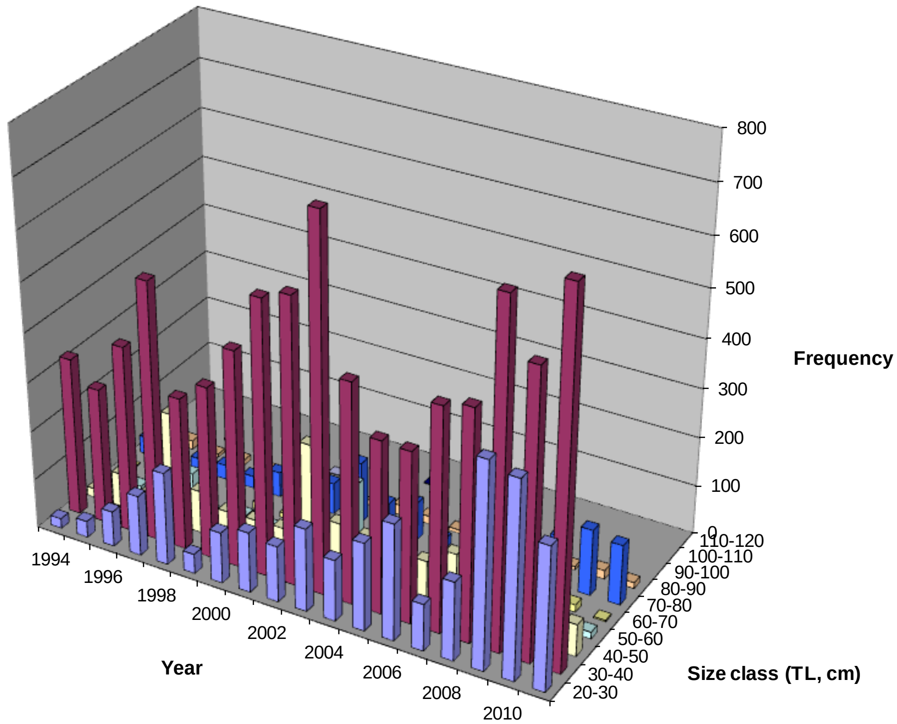


Figure 6. Length frequencies of **Atlantic sharpnose shark** observed in the SEMAP-SA trawl survey (1994-2011).

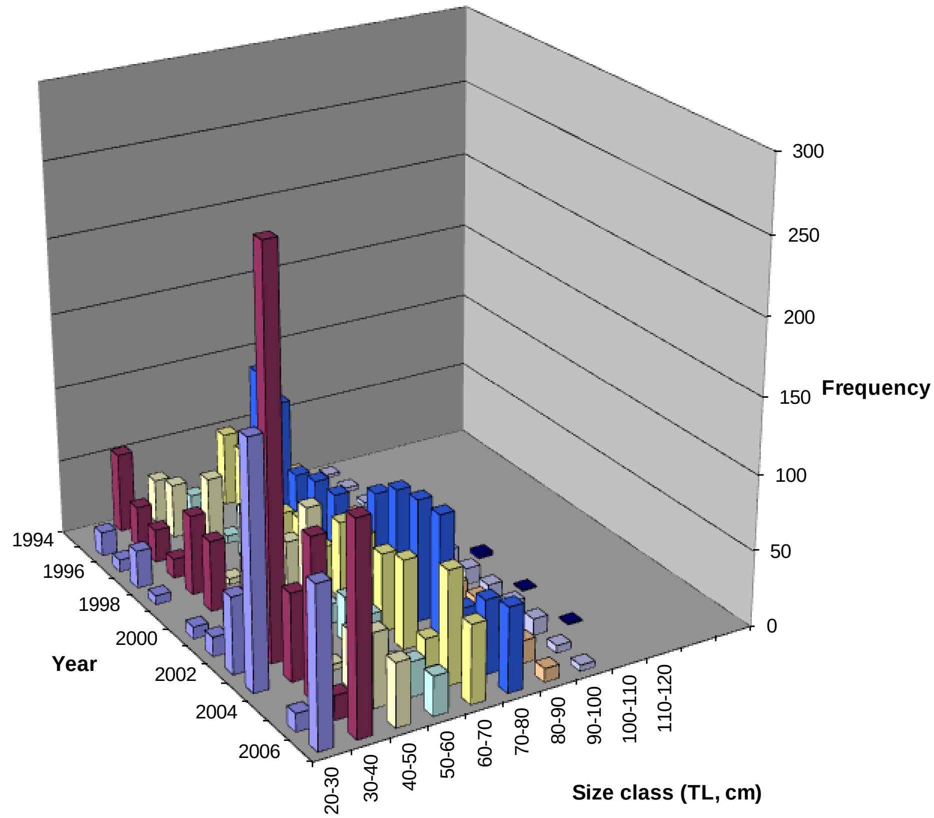
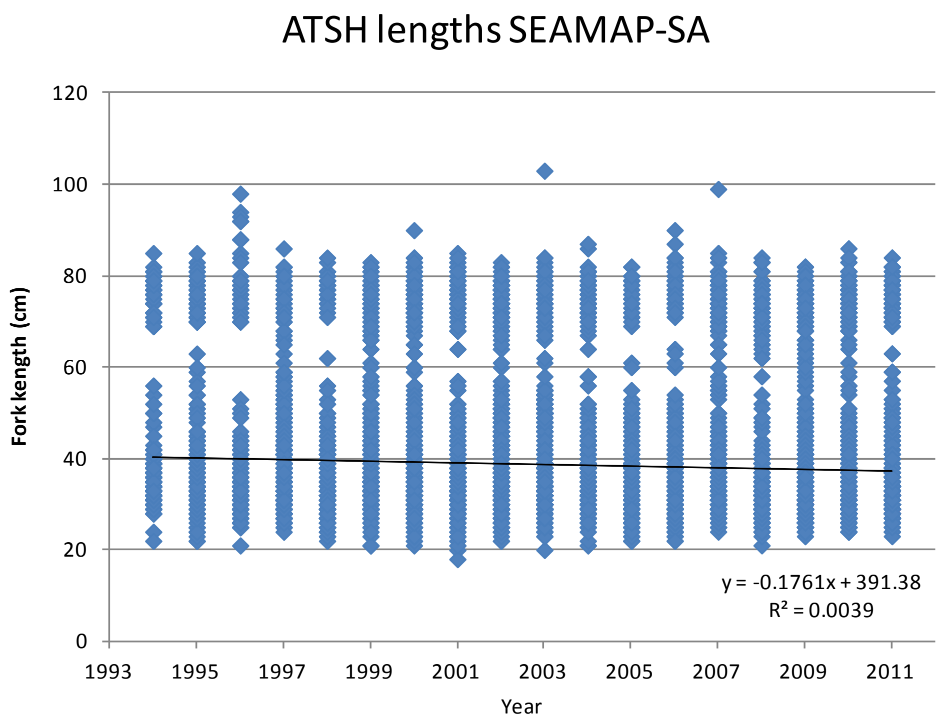


Figure 7. Length frequencies of **bonnethead shark** observed in the SEMAP-SA trawl survey (1994-2011).



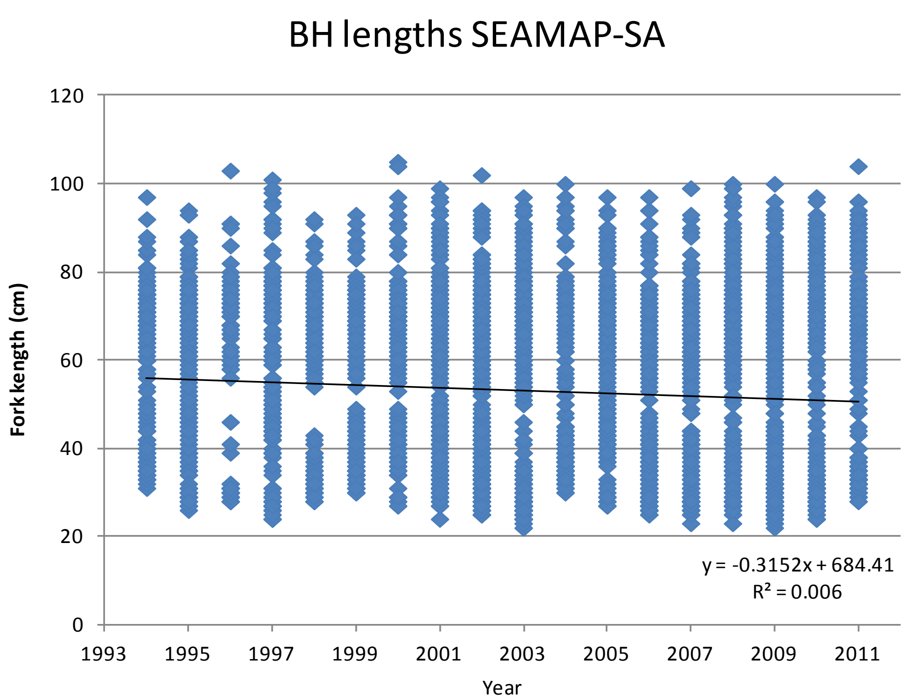


Figure 8. Scatter plot of lengths of **Atlantic sharpnose shark** and **bonnethead shark** recorded in the SEMAP-SA trawl survey (1994-2011).